# Joint Concept Development and Experimentation

*A Force Development Perspective*

Dave Allen
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**Force development activities play a major role in ensuring that the Canadian Forces evolve and adapt to meet future mission requirements. However, the various joint force development activities (capability-based planning, concept development and experimentation) are not closely integrated and frequent changes to these activities have been implemented in recent years. With the intent of guiding potential future changes, this report provides best practices on organization development based on a review of the scientific literature. An assessment of the current joint force development activities and their limitations is then performed. Finally, the paper provides recommendations with regards to Concept Development and Experimentation and how these activities can best contribute to the force development objectives.**

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## Abstract

Force development activities play a major role in ensuring that the Canadian Forces evolve and adapt to meet future mission requirements. However, the various joint force development activities (capability-based planning, concept development and experimentation) are not closely integrated and frequent changes to these activities have been implemented in recent years. With the intent of guiding potential future changes, this report provides best practices on organization development based on a review of the scientific literature. An assessment of the current joint force development activities and their limitations is then performed. Finally, the paper provides recommendations with regards to Concept Development and Experimentation and how these activities can best contribute to the force development objectives.

The report highlights the various aspects that should be part of a systemic force development activity. It is found that some of these aspects are currently ignored within the current capability-based planning approach. These aspects are also used to recommend specific human views that should be included within the Department of National Defence Architecture Framework. The report also highlights that concept development should deliver well defined and precise concepts for which all potential trade-offs have been clearly identified.

## Résumé

Les activités de développement des forces jouent un rôle important lorsqu'il s'agit de faire évoluer les Forces canadiennes de manière à ce qu'elles s'adaptent aux exigences des missions futures. Toutefois, les diverses activités interarmées de développement des forces (planification axée sur les capacités, élaboration et expérimentation de concepts) ne sont pas bien intégrées et ont subi de nombreux changements au cours des dernières années. Dans le but d'orienter les prochains changements qui pourraient être apportés, le présent rapport s'inspire de l'examen de la documentation scientifique pour présenter les meilleurs pratiques en matière de développement organisationnel. S'ensuit une évaluation des activités interarmées de développement des forces et de leurs limites. L'étude se conclut par des recommandations relatives à l'élaboration et l'expérimentation de concepts et concernant la manière dont ces activités pourraient le mieux contribuer à l'atteinte des objectifs de développement des forces.

Le rapport fait ressortir les divers aspects qui devraient être pris en compte dans une activité systémique de développement des forces. On constate que certains de ces aspects ne sont actuellement pas pris en compte dans le cadre de l'approche actuelle de planification axée sur les capacités. On se fonde également sur ces aspects pour recommander certains points de vue humains qui devraient être inclus dans le Cadre d'architecture du ministère de la Défense nationale. Le rapport souligne que l'élaboration de concepts devrait donner lieu à la création de concepts bien définis et précis pour lesquels tous les compromis potentiels ont été recensés avec clarté.

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# Executive summary

## Joint Concept Development and Experimentation: A Force Development Perspective

**Dave Allen; DRDC CORA TM 2012-036; Defence R&D Canada – CORA; February 2012.**

**Background:** Force development activities play a major role in ensuring that the Canadian Forces evolve and adapt to meet future mission requirements. Due to the evolving complexity of the operating environment with a continuous increase of the number of actors, the force development decisions are inherently complex. Military organizations are simultaneously facing a high rate of technological evolution, a less polarized world with many relevant state and non-state actors, and an increasingly complex theatre of operations. These factors combined with the increasing complexity of the organization itself complicate the identifications of issues and therefore the identification of the best direction to orient force development.

**Results:** The current report reviews "organization development" best practices. The term "organization development" has been used in scientific literature to cover all activities performed in support of evolving or modifying an organization. This literature review identified three primary organization interfaces that require close scrutiny for an effective organization development: the organization-environment interface; the group-to-group interface, and the individual-organization interface. The identified best practices are then used as a basis to review and identify limitations of the current force development activities performed within the Chief of Force Development (CFD) organization. It is shown that the individual-organization interface is largely overlooked by the current approach and would need a closer integration with other force development activities. This aspect of organization development is used to recommend specific human views within the Department of National Defence Architecture Framework. The report also includes specific recommendations with regards to improving the Concept Development and Experimentation (CD&E) contributions to force development. CD&E plays an essential role in ensuring the right orientation of the force development activity and in reducing the risk associated to the development of new capabilities.

**Significance:** The best practices described in the current report provide indication on ways to improve the current force development approach within the Canadian Forces. In particular, the report recommends a closer integration of lessons learned and the inclusion of the individual-organization interface within force development activities. The sections focusing on CD&E indicate how to best use these instruments to effectively support force development activities. It is hoped that the arguments provided can help better realign some of these activities.

**Future plans:** A more detailed Concept Development document is being written at the Canadian Forces Warfare Centre. This detailed document will complement the current report as well as the GUIDEx which provides details on defence experimentation.

# Sommaire


## Joint Concept Development and Experimentation: A Force Development Perspective

**Dave Allen; DRDC CORA TM 2012-036; R & D pour la défense Canada – CARO; février 2012.**

**Contexte:** Les activités de développement des forces jouent un rôle important lorsqu'il s'agit de faire évoluer les Forces canadiennes de sorte qu'elles s'adaptent aux exigences des missions futures. L'environnement opérationnel devenant de plus en plus complexe en raison de l'augmentation constante du nombre d'acteurs, il en de même pour les décisions relatives au développement des forces. Les organisations militaires sont confrontées simultanément à une rapide évolution technologique, à un monde moins polarisé comptant de nombreux acteurs étatiques et non étatiques pertinents et un théâtre d'opérations de plus en plus complexe. Ces facteurs combinés à la plus grande complexité de l'organisation en tant que telle rendent plus difficile le recensement des enjeux et, par le fait même, la détermination de la meilleure orientation à donner au développement des forces.

**Résultats:** Le rapport actuel porte sur les meilleures pratiques en matière de « développement organisationnel ». Le terme « développement organisationnel » est utilisé dans les textes scientifiques pour désigner toutes les activités menées à l'appui de l'évolution ou de la modification d'une organisation. Dans le cadre de cet examen de la documentation, on a relevé trois principales interfaces organisationnelles qu'il faut étudier de plus près pour un développement efficace : l'interface entre l'organisation et le milieu; l'interface entre deux groupes et l'interface entre l'individu et l'organisation. On se fonde ensuite sur les meilleures pratiques recensées pour examiner et reconnaître les limites des activités actuelles de développement des forces menées au sein de l'organisation du Chef - Développement des forces (CDF). Il est démontré que l'approche actuelle ne tient pas beaucoup compte de l'interface entre l'individu et l'organisation et que cette dernière devrait être davantage intégrée aux autres activités de développement des forces. On part de cet aspect du développement des forces pour recommander l'apport de certains points de vue humains dans le Cadre d'architecture du ministère de la Défense nationale. Le rapport comprend aussi certaines recommandations concernant l'amélioration des contributions de l'élaboration et expérimentation des concepts (EEC) au développement des forces. L'EEC est essentielle pour bien orienter l'activité de développement des forces et pour réduire les risques associés au développement de nouvelles capacités.

**Importance:** Les meilleures pratiques décrites dans le présent rapport présentent des façons d'améliorer l'approche adoptée actuellement dans les Forces canadiennes en matière de développement des forces. En particulier, le rapport recommande une meilleure intégration des leçons retenues et l'inclusion de l'interface entre l'individu et l'organisation dans les activités de développement des forces. Les sections portant sur l'EEC démontrent la meilleure façon d'utiliser ces instruments pour appuyer efficacement les activités de développement des forces. Il est à espérer que les arguments présentés contribueront à mieux harmoniser certaines de ces activités.

**Recherches futures:** Un document plus détaillé sur le développement des concepts est en voie d’élaboration au Centre de guerre des Forces canadiennes. Le document en question complétera le rapport actuel ainsi que le GUIDEx qui fournit des précisions sur le processus d’expérimentation dans le domaine de la défense.

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# 1 Introduction

## 1.1 Background

Contemporary organizations are facing an environment evolving at an unprecedented pace. New technologies are emerging continuously and an increasing number of actors are capable of having political and economic ramifications at the international level. In response to these changes, organizations must continuously evolve and adjust. In fact, empirical data indicate that even in a relatively stable environment a certain level of organization evolution tends to increase the organization stability [1]. All these factors clearly highlight the importance of organization development.

From a military perspective, organizations are simultaneously facing a high rate of technological evolution, a less polarized world with many relevant state and non-state actors, and an increasing number of armed and unarmed (aid and development) organizations operating within their Area of Operations. In the past, military force development was largely performed in response to the evolution of the main opponent capability. However, current military development must consider a much larger variety of possible opponents and keep track of a large number of new technologies, continuously evolving. Within this context, concept development and experimentation are important activities to ensure appropriate guidance to military force development and to reduce the time required for the acquisition of new capabilities.

## 1.2 Aim of the Report

The aim of this report is to review organization development best practices to establish references against which the current joint force development can be assessed. These best practices consider both the aspects and the steps that should be part of the organization development activities. Three aspects appear particularly important to organization development activities: the organization-environment interface, the group-to-group interface, and the individual-organization interface. In addition, four steps are essential to any organization development procedures: identifying existing or upcoming issues, identifying directions in which to develop the organization, implementing the required modifications, and assessing the impact of the implemented changes. The three aspects and four steps are used to establish a framework on which to compare the current joint force development process. It is found that the current force development approach should strengthen its current focus on the individual-organization interface and should also better integrate joint lessons learned. The identified aspects of organization development are also used to recommend specific human views for inclusion within the Department of National Defence Architecture Framework (DNDAF).

The second half of the report provides additional recommendations with regards to the Concept Development and Experimentation (CD&E) activities. These activities play particular importance in ensuring the adequacy of proposed force development solutions and reducing the risk associated with the implementation of these solutions. Considering the three aspects and four steps, it is indicated how the CD&E activities can be beneficial to force development.

This report will provide useful information and guidelines to the broader military community recently involved in force development and/or CD&E activities (Directorate of Military Capability Management, the Cyber Task Force, as well as the Joint Information and Intelligence Fusion Capability (JIIFC) project, the Collaborative Operational Planning System (COPS) project, the Chief of Defence Intelligence (CDI), the Strategic Joint Staff (SJS), 1st Canadian Division, the Chief of Programs (CProg), the Canadian Expeditionary Forces Command (CEFCOM), Canada Command (CanadaCOM), and the Canadian Operational Support Command (CANOSCOM)).

## 1.3 Outline

The report is divided as follows:

- Section 2 describes primary organization development models used in management science. This first section provides a broader context on force development and its purposes. The described model is used to build the framework that is used in the following section to review the current force development methodology used within the Canadian Forces.

- Section 3 discusses the current force development process as performed by the Chief of Force Development (CFD) organization. This section focuses on the central item of the force development approach which is based on a Capability-Based Planning (CBP) methodology. This approach is compared with the scientific model of organization development introduced in section 2. This comparison is of particular interest within the context of the on-going activities to develop a new version of the Strategic Capability Roadmap (SCR). This section highlights the limitations of the current force development activities and provides recommendations to more closely align these activities to existing best practices.

- Section 4 focuses the discussion on concept development activities. The specific contributions of concept development are discussed and recommendations are made to ensure the effectiveness of these contributions considering the various aspects that force development should include.

- Section 5 is similar to section 4 with the exception that the focus is now on experimentation activities and its contributions to force development. This section is largely based on The Technical Cooperation Program (TTCP) Guide for Understanding and Implementing Defense Experimentation (GUIDEx). [27]

- Section 6 concludes and provides the reasoning for a more integrated approach between the various force development activities.

# 2 Organization Development Sciences

## 2.1 A System-of-Systems Approach

Within the context of management science, organization development is defined as the set of activities performed for finding and implementing ways to change the organization from its current state to a better-developed state. This entails four types of activities[1]: 1) identifying existing or upcoming (i.e., future) issues; 2) identifying directions in which to develop the organization; 3) implementing the required modifications; and, 4) assessing the impact of the performed changes. This seemingly simple sequence of tasks is rendered complex by the plethora of subjective views that impact each task. In particular, one should note that the identification of issues is matter of perception. If one subjectively perceives an activity or its outputs more difficult to complete than expected, then he will associate specific issues to this activity. Therefore, issues are subjective and relative to expectations.

Force development (FD) is becoming more complicated due to the increasing complexity of organizations. In particular, the organizational boundaries are becoming blurry. Some firms, such as Walmart, are becoming more interconnected with their merchandise providers and in some cases sharing databases and infrastructure. Also, various organizations have external contractors closely embedded within their own units making the distinction between internal and external organization aspects less obvious. All these factors increase the organization's complexity and complicate the identification of the root cause for identified issues and the prediction of the impact of specific changes.

Organization development was initially done primarily by behavioural scientists and focused on improving staff training. However, researchers have highlighted the need for a broader approach to organization development (see references [2] and [3]). In particular, Lawrence and Lorsch have shown the importance of having a systemic approach to organization development. They suggested looking at organizations from three different perspectives (see Figure 1 where the organization is depicted by the large black box within a conceptual space):

1. The group-to-group interface (shown in green in Figure 1);

2. The individual-organization interface (shown in red in Figure 1 and indicating the boundary between the organization and the various individuals contributing to it); and,

3. The environment-organization interface (shown in blue in Figure 1 and indicating the boundary between the organization and the external environment – the term "environment" is used to refer to all entities external to the organization and the individuals contributing to it).

These three perspectives reflect crucial and essential elements for organization development: the necessity for each unit to have characteristics consistent with its task and for unity of effort; the necessity for satisfactory inducements to ensure individuals agree and are motivated to contributing to the organization; and, the necessity of developing an effective relationship and transaction with the environment.

[1] The four identified steps are similar to the four steps of the OODA loop: Observe, Orient, Decide, Act.

Note that within the Lawrence-Lorsch model, individuals are external to the organization; all individuals exist outside the organization highlighting the fact that any long term organization planning needs to consider the transient nature of the individuals and the associated need for recruitment and transfer of knowledge. Only the individuals' contributions to the organization are integral to it.

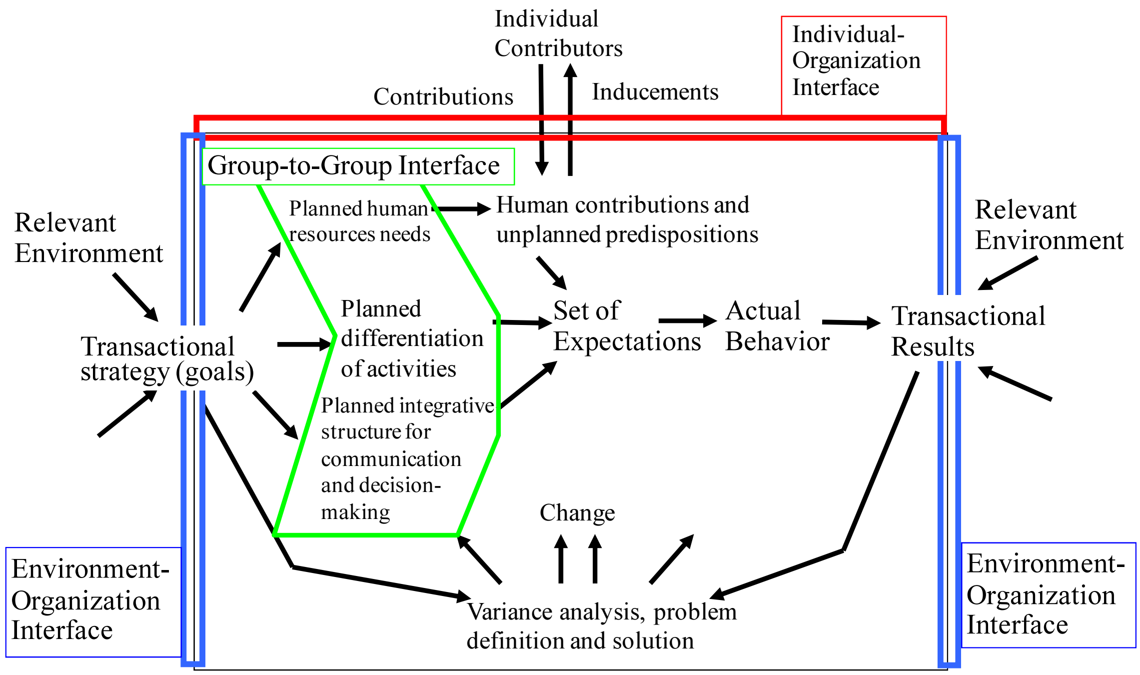


*Figure 1: Lawrence and Lorsch organization model*

## 2.2 Environment-Organization Interface

The Lawrence-Lorsch model provides a large number of factors that can be considered and modified in response to an organization development need. At the environment-organization interface, staff must secure and process deals as well as negotiate the terms of exchange of tangible goods and less tangible services of many kinds. However, this interaction with the environment might vary between organizational units. Some units, such as an R&D unit, might have to deal with a very uncertain environment with emerging new technology that can disrupt the organization's ability to perform within its environment. Lawrence and Lorsch recommend the consideration of four measurable features to allow each unit to adequately adjust to its environment:

1. The degree of reliance on formalized rules and formal communication channel within the unit;

2. The time horizon of managers and professionals in the groups;

3. Their orientation toward goals, either diffuse or concentrated; and

4. Their interpersonal style, either relationship or task oriented.

If the environment is relatively stable, the necessary information can be handled through the traditional superior-subordinate channels, which may be few and constricted but are less subject to error and relatively inexpensive. Fairly short time horizons are adequate to take account of the reactions of the environment to the firm's action. The interface can be designed on a straightforward task-oriented approach.

On the other hand, to deal with an uncertain and rapidly changing sector of the environment, more points of contact and a flatter organization must be employed. Formal rules cannot be formulated that will be suitable for any appreciable time period. More of an all-to-all communication pattern is indicated, which can keep environmental clues moving throughout the unit for interpretation at all points instead of just through superior-subordinate channels. A longer time orientation is usually needed. The growth of this more complex and sophisticated communication network is fostered by an interpersonal style that emphasizes building strong relationships rather than just accomplishing the task, per se.

## 2.3 Individual-Organization Interface

The crucial question at the individual-organization interface is how individual contributors can be induced to perform their defined activities. How can we motivate individuals to make the contributions to the organization purpose that is required of them? How can the organization channel and control the behaviour of individual contributors in the desired direction? These questions require a look at what motivates individuals. Schein identified three important motives [4][2]:

- Need for achievement: Need for competitive success measured against a personal standard of excellence.
- Need for affiliation: Need for warm, friendly, compassionate relationship with others.
- Need for power: Need to control or influence own activities and possibly those performed by others.

Schein grouped these motives under a global need for problem-solving (or as termed by White, a need for a sense of competence or mastery [6]). As the individual system strives to solve problems, certain behaviours turn out to be consistently rewarding; that is, they provide solutions to the problems the individual faces. Over time, as some behavioural patterns (patterns of success, control, friendly relationship, etc.) are consistently rewarding, the individual learns to rely on them.

The problems and challenges perceived by an individual in the organizational setting is shaped by the expectations of others, by the nature of the task which the individual is required to perform

[2] More recently, Daniel H. Pink came to a similar conclusion with regards to the key motives impacting an employee's contributions [5]. He used the term autonomy, mastery and purpose to summarize the motives. Respectively, according to Pink, these three terms expressed the employee's need to choose what and how tasks are completed, the need to become adept at an activity, and the desire to improve the world. These three motives have a close similarity to Schein's needs for power, achievement, and affiliation.

and by the formal organization variables, such as supervisory style, rewards and punishments, rules, control procedures, etc., with which he is confronted. The individual system, others' expectations, the task and formal organization variables all help shape the individual's view of what is expected of him by the organization.

This conceptual scheme highlights two opportunities for developing the individual-organization interface:

- Developing the individual systems to make them more consistent with the rewards available from task and organizational factors.
- Alter the task or organizational variables so that they will afford a higher expectation of need satisfaction.

Such an approach to developing the individual-organization interface means placing a heavy emphasis on diagnosis. We need to identify in what activity groups problems exist. What are the attributes of these jobs and what behaviour leads to effective performance? What individual system characteristics are most likely to motivate individuals to perform this sort of task effectively? Are the expectations of others, the organizational relationships, rewards, and controls likely to motivate individuals to perform this sort of task effectively? Are the expectations of others, the organization relationships, rewards, and controls likely to work toward increasing the expectation of need attainment, or will they operate in the opposite direction?

## 2.4 Group-to-Group Interface

To manage a large complex organization, it is common to divide it into units that can function nearly independently of each other. This division reflects the common view that the grouping of specialized units will outperform a team of generalists with regards to the quality of the task output and of their productivity.

Three aspects need to be considered when considering the division of the organization into modular units:

- The resources (human, authorities, responsibilities, etc.) assigned to each units;
- The level of differentiation of the organization into units;
- The level of integration between units and the communication and technical tools supporting this integration.

The level of differentiation within an organization depends upon what internal characteristics each group must develop to carry out planned transactions with its assigned part of the environment. More specifically, it depends primarily upon the extent to which the certainty of information within the various parts of the environment is similar or different. The differentiation of the organization into units ensures a certain modularity reinforcing the organization robustness.

The objective of organization development efforts at the group-to-group interface is to achieve collaboration or integration between the groups of specialized contributors so that they can make a coordinated effort toward total organization goals, while still working effectively at managing the transactions with their particular segment of the environment.

Integration between groups deals with two aspects: which units are required to work together and how tight the requirement is for interdependence among them. When units are highly differentiated, it is more difficult to achieve integration among them than when the individuals in the units have similar ways of thinking and behaving. As a result, when groups in an organization need to be highly differentiated, but also require tight integration, it is necessary to develop more complicated integrating mechanisms. Organization integration research provides a list of factors that impact on the level of integration. Barki and Pinsonneault have recently proposed an Organization Integration model [7] which is characterized based on the number of firms involved (internal: within a single organization; external: involving at least two firms) and on the type of integration: procedural (integration across procedures) or functional (integration by providing additional functionalities). The Barki and Pinsonneault model also integrates the type of interdependency as introduced by Thomson [8]. Three types of interdependencies were introduced by Thomson: Pooled, Sequential or Reciprocal. Pooled interdependency is the simplest and corresponds to the functional integration where the various integrated organizations share common pooled resources. Sequential interdependency implies that the output of one organization is used as input by the other. The reciprocal interdependency is the most complex and implies back and forth procedural interaction between the organizations. This model indicates that an organizational division to reduce the need for procedural integration as well as reciprocal integration is ideal. The model also provides a list of mechanisms that can be used to achieve the required integration:

- Mutual team adjustment;
- Direct supervision;
- Standardization of output;
- Standardization of work;
- Standardization of skills and knowledge;
- Standardization of norms; and,
- Pre-planning.

Mutual team adjustment and direct supervision will require communication systems if the various units are not co-located. It also requires trust and understanding between groups and the confrontation of conflict. Too often specific conflict-management variables are not considered, such as those that are contingent on environmental demands; on the required state of differentiation; and also on the design of appropriate structural devices for achieving integration.

The Barki-Pinsonneault model is not limited to a single organization, but could also be considered for assessing the level of integration across different organizations (e.g., the model was recently used for assessing the level of organization integration for a multi-national operation where military units from different countries share a common airspace [9]). For example, within a coalition setting or a Whole-of-Government approach, the applications of specific mechanisms, such as direct supervision, are limited due to the limited accountability enforced between the various organizations. Constraints are only self-imposed by agreeing to specific treaties. These limitations increase the reliance on the other mechanisms to ensure an adequate integration of all organizations involved within the coalition.

## 2.5 Summary of Organization Development

The various elements of the Lawrence-Lorsch organization development model are summarized in Figure 2.

Not all factors identified by the Lawrence-Lorsch model can be as easily modified to perform organization development. Some factors require a more fundamental behaviour change, which are less easily implemented. Table 1 summarizes the list of possible targets for changes and display their associated behaviour change. This table shows that a modification of the tools and of the interaction patterns (tactics, techniques and procedures) are the simplest to implement and should be sought prior to more disruptive approaches. Note however that the change methods do not necessarily impact a single change target. For example, an intensive educational program would in the long term impact an individual's basic motives. The association made within Table 1 should be considered as the primary target associated with the change methods.

*Table 1: Hierarchy of organization development changes*

| | **Change Target** | **Change Method** |
|---|---|---|
| Modest Behaviour Change | Simplifying human resource needs | Technical support to human contributions; automation of routine and redundant tasks |
| | Different interaction patterns | New coordination methods, budgets, schedules, official channels of communication; database integration |
| | Different role expectations | Intensive educational programs; new divisions of labour and authority structure |
| | Different orientations and values | New reward systems; different leadership styles |
| Fundamental Behaviour Change | Different basic motives (achievement, power, affiliation) | New selection criteria; replacement or incumbents; or major strategy change |

For complex changes impacting several change targets, a system-engineering approach (see [10]) such as the V-model is recommended (see Figure 3). Note that the stakeholder requirements, which are obtained by focusing solely on the problem-space corresponds to the first step of identifying issues. These stakeholder requirements might relate to any of the three identified interfaces. Each interface relates to different subsystems within an organization. For example, the group-to-group interface is associated with the integrating and communication subsystem while the individual-organization interface refers to the reward, supervisory, control procedure subsystems. The principal benefit of the Lawrence-Lorsch model is to provide a framework according to which an organization is subdivided into three complementary interfaces that can be used as the basis on which organization development is done. The organization development best practices highlight the importance of the first two steps which consist of identifying existing or upcoming issues and identifying directions in which to develop the organization. These two steps are essential for the establishment of the stakeholder requirements on which the whole development activity depends. The importance of these steps is further supported by investigating the reasons for failure of organization development activities.

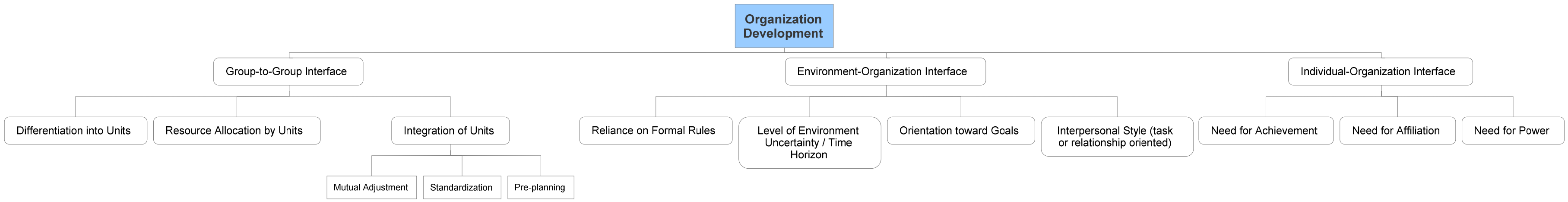


*Figure 2: Overview of Lawrence-Lorsch organization development model*

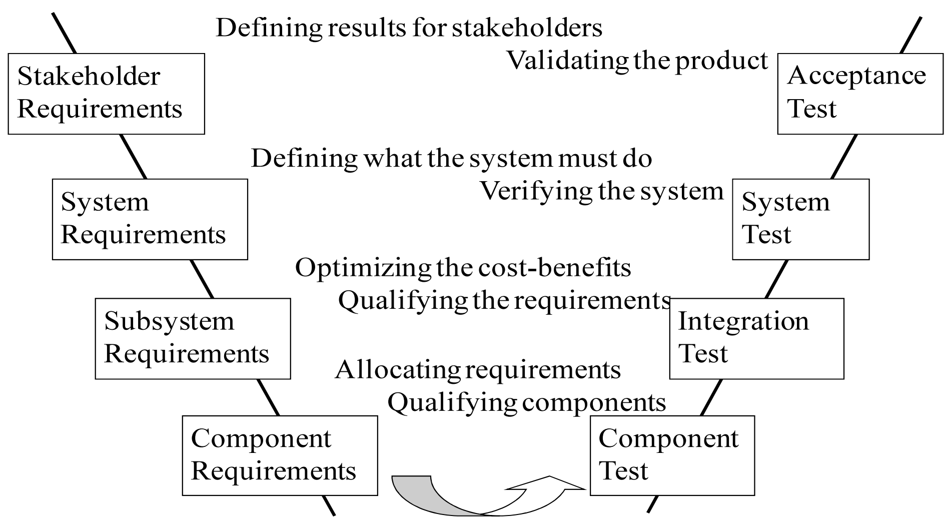


*Figure 3: V-Model for systems engineering.*

Table 2 provides the results of a survey performed by the Standish Group in 1995 and 1996 to identify the different reasons for project failure (see [10] for a description of the survey results). Although this survey considered general projects, it is certainly applicable to organization development projects. The survey was distributed to a large number of staff members within several private firms. The staff members were requested to identify reasons behind the failure of projects in which they were involved. The various identified reasons were then clustered in different categories, for which the most frequent ones appeared in the left column of Table 2. This survey indicates that the most common reason for project failure is the incomplete set of requirements. This result highlights the importance of having a model such as the Lawrence-Lorsch model to ensure a systemic consideration of all aspects implied by the organization development project. The danger of "lack of user involvement" also shows the importance of staff member involvement in ensuring the right direction for organization development.

*Table 2: Reasons for project failure*

| **Reasons** | **Percentage** |
|---|---|
| Incomplete requirements | 13.1% |
| Lack of user involvement | 12.4% |
| Lack of resources | 10.6% |
| Unrealistic expectations | 9.9% |
| Lack of executive support | 9.3% |
| Changing requirements/specification | 8.7% |
| Lack of planning | 8.1% |
| Did not need it any longer | 7.5% |

# 3 Force Development

## 3.1 Role of the Chief of Force Development

Force development is the procedure instituted within the Canadian Forces to ensure that the Canadian military will be successful in meeting the missions of tomorrow. At the joint level, this activity falls under the purview of the CFD, whose mandate is defined as follows:

- Harmonize, synchronize and integrate the force development activities of the Environment Chief of Staff and functional L1s;
- Focus on development of integrated capabilities by formalizing CBP, Capability Management (CM) and Capability Production (CP) in a coherent end-to-end Force Development process; and,
- Provide a unified Force Development "drumbeat" or "battle rhythm".

Within this role, the CFD has established the force development process as displayed in Figure 4. The force development process is displayed in the middle part of the figure. Foreign and Defence policies are used to develop a picture of the future security environment. This initial work leads to the development of force development scenarios describing the likely missions involving the future CF and describing the context in which these missions will be performed.

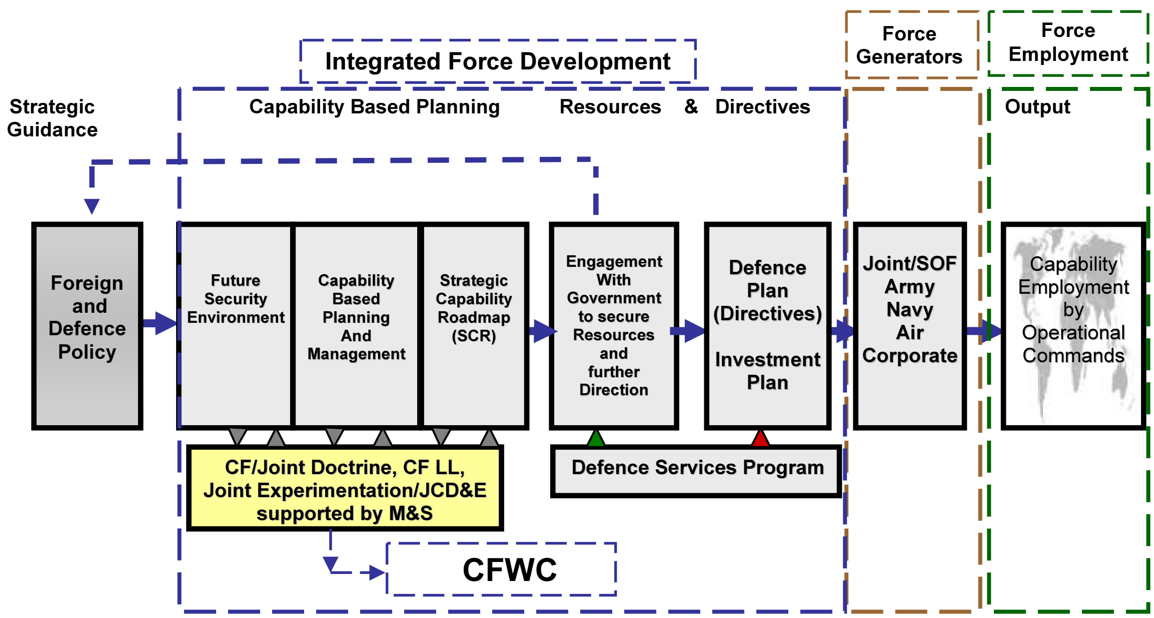


*Figure 4: Overview of the CF force development process*

## 3.2 Capability-Based Planning

Once a picture of the future security environment has been established, a CBP process is initiated. This process includes three subsequent phases leading to the development of a SCR, which feeds into the Investment Plan (IP). The three phases consist of (see Figure 5):

- Capability analysis: Investigate and prioritize the list of capabilities required to meet the missions within the future security environment.
- Capability assessment: Compare the forecasted CF capability with the required set of capabilities based on the capability analysis for identifying investment, divestment, and sustainment (IDS) priorities.
- Capability Integration: Develop courses of action for meeting the IDS established priorities.

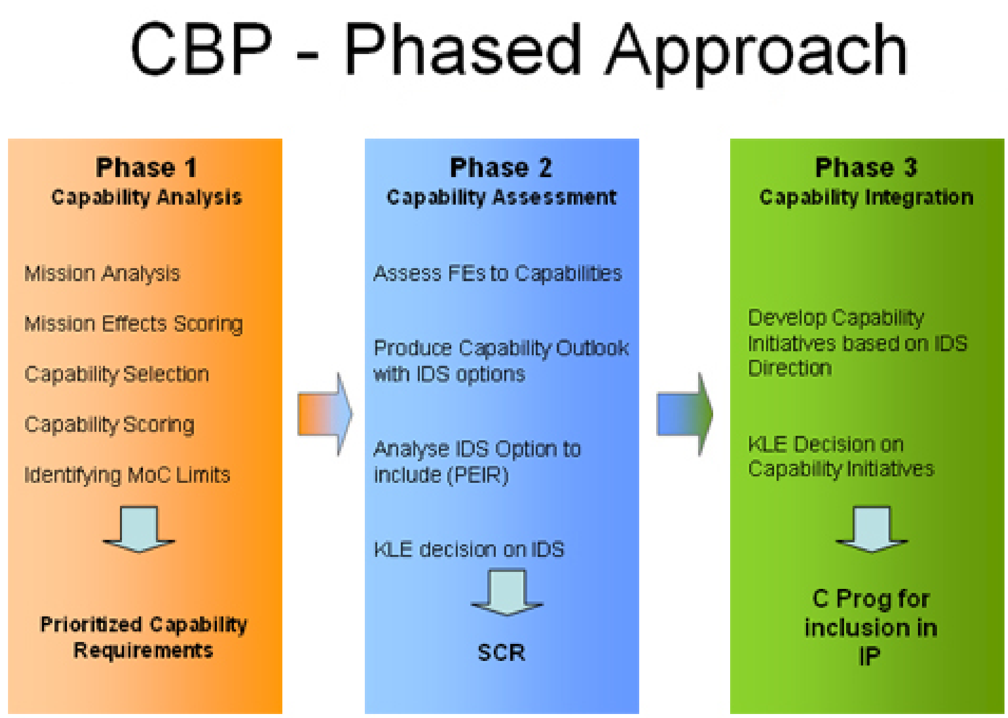


*Figure 5: Overview of the capability-based planning process*

Within the CBP process, a capability is not reducible to a simple set of equipment. In fact, the force development staff members are requested to incorporate all of the PRICIE elements (see Figure 6) in their analysis of required capabilities. Capabilities require trained and ready personnel supported by adequate equipment, infrastructure, doctrine, procedures, and Information Technology systems. All these various aspects are supported by Research and Development activities, which contribute to the development of the required capabilities.


*Figure 6: Overview of the PRICIE Elements*

## 3.3 CBP Versus Organization Development Best Practices

The PRICIE approach to capability development covers a large portion of the organization development components proposed by Lawrence and Lorsch. Table 3 shows the mapping between the various PRICIE elements and the list of change methods proposed by Lawrence and Lorsch (see Table 1). The Research, Development and Operational Research aspect of PRICIE is not indicated as it permeates all the proposed change methods.

*Table 3: Comparison of Lawrence-Lorsch change methods with PRICIE elements*

| Change target | Change method | PRICIE Elements |
|---|---|---|
| Simplifying human required contributions | Technical support to human contributions; automation of routine and redundant tasks | IT systems, Equipment |
| Different interaction patterns | New coordination methods, budgets, schedules, official channels of communication, database integration | Doctrine, collective training, IT systems |
| Different role expectations | Intensive educational programs; new divisions of labour and authority structure | PD & Leadership, Infrastructure & Org |
| Different orientations and values | New reward systems; different leadership styles | PD & Leadership |
| Different basic motives (achievement, power, affiliation) | New selection criteria; replacement or incumbents; or major strategy change | PD & Leadership |

Interesting conclusions can be deduced from this mapping of the PRICIE elements: changes involving the PD & Leadership and Infrastructure & Organization elements of PRICIE imply a stronger behaviour change (since they are associated with factors further down on the list of Lawrence and Lorsch scale – see Table 1) and will therefore require more time and effort to lead to an effective modification of the organization.

Notwithstanding that the PRICIE elements cover most of the Lawrence and Lorsch elements for organization development, the scenario-based approach used within the CBP methodology to force development provides only a limited perspective to the broader organization development proposed by Lawrence and Lorsch. Essentially, the scenario-based approach is largely limited to the environment-organization and group-to-group interfaces perspective. It focuses on likely missions that will be required of the Canadian Forces and the associated required capabilities both for dealing with the environment and for ensuring the right level of integration (this focus being mostly under the Command, Control, Computer and Communication (C4) aspects of the missions). Therefore, the CBP approach aims at answering questions such as:

- What equipment, doctrine, training, and human resources will the Canadian Forces need to meet the future threats and mission requirements?

The situation can be summarized as follows: Although, various human factors are considered within the capability engineering approach (through the PRICIE methodology), the step which consist of “identifying current or future issues” (identification of the needs, which is scenario based) does not consider the individual-organization interface.

## 3.4 Capability-Based Planning Limitations

Our review indicates that the individual-organization interface is largely overlooked by the scenario based approach. As argued by Lawrence and Lorsch, this interface requires a large diagnostic effort (identifying the current status of the organization at the individual level), which is not the main focus of the scenario-based approach. In consequence, the current CBP approach will not provide answers to questions such as:

- Is there a healthy diversity of views across the various CF units or is there too many conflicting views leading to a waste of efforts?
- Are the employees thinking in terms of simply a job or of a career?
- How much emotional commitment to organization goals is offered and expected?
- What balance is struck between dependence and independence, between conformity and creativity, between duty and self-expression?
- Is the organization accumulating a reservoir of trained human assets and good will, or is it dissipating human resources built up in an earlier period?
- What balance of efforts respectively goes into CBP, CF units’ integration and resource motivation efforts? Is the distribution of efforts adequate?
- Is the ratio between reservist, regular forces and public servant adequate considering the motivation and expectation of each group respectively to the organization need?

These remarks highlight the fact that the CBP approach cannot be the sole approach to organization development. This conclusion might not be surprising as other units, in addition to CFD, participate in one way or another to the force development effort (through recruiting, training, etc.). However, it invites additional questions such as: Can the CBP process be performed independently of other organization development activities? Future military activities, equipment, training will impact the individual-organization interface (impact on the individual's expectation, on rate of retention, etc.) and therefore a broader approach to force development may be desirable. This conclusion is in agreement with decision-making best practices [12] which indicate that the impact resulting from the implementation of organization changes on human motivation are crucial and should be considered within the selection of possible force development options. Therefore, a strategic lesson process that is considering the organization at large including the level of satisfaction among the CF members and their view on the overall organization should be established to gather the required information to steer the force development process in the right direction.

## 3.5 DNDAF Human Views

The existing Department of National Defence Architecture Framework (DNDAF version 1.7) incorporates various views that can be used to guide force development activities. Apart from the Common Views, Strategic Views, and Capability Views that are used more to set the context, the other architecture views are centered around four items and their interconnection (see Annex A for a details of the various views): the people, the technical system, the established procedures, and the required information.

The various views provide much of the information discussed within the Lawrence-Lorsch model of organizations. For example, the differentiation of activities into different groups and the relationship between these groups are described by the Operational View (OV) 4 views. Similarly, the transactions between the organization and the environment are captured within the Capability Scenario Analysis Matrix (Capability View 2) that describes the various mission effects. However, even though the skill set required by the staff members and their expected activities are described by specific operational views (respectively the OV-4b and OV-5a), the individual-organization interface is currently not captured within any architecture views. To remedy this limitation, it is suggested to add Human Views to the list of architecture views. The description of the individual-organization interface suggests structuring the human views into three categories based on Schein motives (see section 2.3): human achievement, human affiliation, and human power/leadership. Diagrams could display the degree of fulfillment of these different individuals' needs for each possible trade as well as the activities, program and policies set to support these needs. The requirements specified within these diagrams would also generate additional process models to be included within the operational views (OV-5b). This generation would ensure the coherence of the various views.

# 4 Concept Development

## 4.1 Introduction

The previous chapter provided a review of the joint force development activities using organization development best practices. This review was limited to the first two main steps within the force development activities (see Figure 4): the development of scenario based on the Future Security Analysis and the Capability-Based Planning process. However, additional activities are performed within the force development process: in particular, concept development and experimentation (CD&E). This section focuses on the contributions of concept development to the organization development process and the implications of organization development best practices on concept development activities.

## 4.2 Concept Definition

Within the force development context, a concept is defined as a notion or statement of an idea, expressing how something might be done or accomplished, that may lead to an accepted procedure. More precisely, the concepts describe the method (ways) for employing military capabilities (means) to accomplish given missions (ends). Military concepts inform the CBP process by providing a prescriptive way of employing future capabilities to meet future missions.

At the joint level, a broad number of concepts have been defined and developed: [13]

- The Future Security Environment (FSE): A strategic level concept that analyzes international emerging trends, places them into a Canadian context, and describes the future type of missions that the CF will accomplish.
- Integrated Capstone Concept (ICC): A basic, strategic-level Operating Concept, which provides a broad description of how future forces will operate across the assigned range of military operations in accordance with government direction. It turns the FSE and Scenarios into an analysis of the operational requirements of the CF and the effects required to be strategically relevant, operationally responsive and tactically decisive in the FSE.
- Integrating Concepts (IC): Concepts that identify the effects and attributes required by the future CF in order to meet a specific mission or condition set. They describe how various broad core operational activities relate and how they can be integrated into a cohesive operating system within the future CF. In particular, they describe how Defence must be integrated beyond joint and combined to include relationships between Defence and external organizations and the level of interoperability needed with those organizations to successfully achieve its goals.
- Operating Concepts (OC): Concepts that describe the "how" within the constraints and restraints of the integrating concept and scenario generated from the FSE. While the IC identify the strategic effects and force attributes for future defence capabilities, the related operating concepts describe how those capabilities could be employed within a particular mission or condition set.

- Enabling Concepts (EC): Strategic, operational or tactical concepts that cover the entire range of condition sets where technologies (i.e., Artificial Intelligence) or methodologies (i.e., Comprehensive Approach) affect the nature of future operations. If a methodology or technology is key to delivering the effects described by a particular integrating or operating concept, then it becomes an "enabler".

It should be obvious from this description that a hierarchy exists among the various concepts. Figure 7 illustrates the relationships among the various concepts. The ICC uses the FSE as input to identify primary requirements for the future CF (explicitly the need for an integrated, comprehensive, adaptive and networked force). The ICC is used as input to the IC, which identifies the force attributes required and describes how the core activities will be integrated to respond to each mission expected of the CF. The OC describes how each identified attribute will operate within each environment (land, air, maritime, space, cyber, and cognitive[3]).

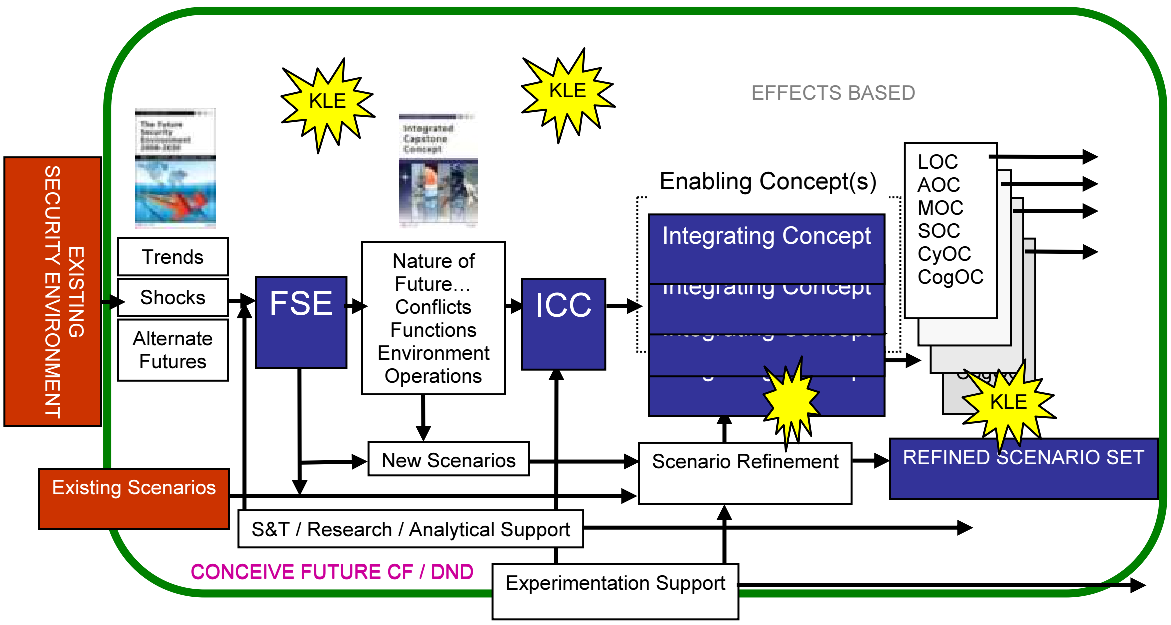


*Figure 7: Hierarchy of force development concepts*

## 4.3 Concept Requirements

The broad definition of concept leads to a plethora of possible subordinate or supporting concepts. Considering the list of possible military capabilities, going from the capability to sense changes within the environment to the capability to deliver fires at a distance while minimizing the risk of fratricide and keeping the soldiers well protected, one ends up with many possible concepts that could be written on how to employ each of these capabilities. Furthermore, when coupled with the consideration of the potential circumstances under which each capability could

[3] More recently the "cognitive" domain was removed as one of the CF operating domains and is now considered as an aspect that must be considered throughout all of the operating domains (land, air, maritime, space and cyber).

be employed and of how to integrate various packages of capabilities into an effective set to meet specific mission requirements, one ends up with an even much larger list of potential concept papers. The resulting question is how to select the concepts worth developing. Scientific considerations as well as force development considerations provide answers to this question.

From a scientific perspective, concepts are introduced to explain some phenomena. As described by Carnap [15], the scientific concept development proceeds through two stages: first, the considered phenomena must be clarified sufficiently for scientists to know what requires explanations; second, an exact concept must be precisely articulated. Carnap also indicates four criteria according to which concepts are to be judged:

1. Similarity to the phenomena. If the concept does not incorporate a model that replicates adequately the phenomena to a sufficient degree, it cannot fulfill its function. A perfect match cannot, however, be demanded, as phenomena occur in a more complex world that can be elaborated through concepts.

2. Exactness. Unless the concept is precise it does not fulfill the purpose of "explaining" the phenomena.

3. Fruitfulness. The new concept should enable us to deduce meaningful conclusions and important insights. One of the main benefits should be to deepen our understanding of the nature of sciences.

4. Simplicity. The concept should be as simple as requirements 1 to 3 permit. Simplicity often accompanies systematic power of concepts and aids in ease of application and avoidance of errors of application.

Within the list of Carnap criteria, criterion 4 is subordinate to its predecessors. Thus criteria 2 and 3 take precedence; we seek useful concepts that are formulated with precision. In sciences, the use of mathematical formulations ensures the later requirement of precision while the competition among scientists for funding encourages useful concepts.

## 4.4 Concept Development Benefits to CBP

Within the military, concepts are ultimately developed to indicate new ways of achieving specific military objectives or to clarify existing ways that lack rigor or precision. Therefore, concept development requires some knowledge of current doctrine. The required knowledge is particularly important for the development of joint concepts. Without the required knowledge, ideas such as "centralized command and decentralized control" are proposed without a clear understanding on the impact such ideas might have on the operations (see [16] as a reference on similar issues).

From a CBP perspective, concept development supports the following activities:

- Description of the future operating environment and the threat that the CF will face;
- Identification and categorization of required capabilities to meet future missions; and,

- Assessment of the direction in which the required capabilities will be designed and employed (informs the Investment, Divestment and Sustainment priorities).

Within the "Conceive-Design-Build-Manage-Employ" phases of capability development and management, concept development enters primarily in the "Conceive" portion, but it also informs all phases including the "Employ" phase (e.g., it informs the development of the relevant doctrine).

The FSE clearly satisfies the first CBP demand. Also, the FSE, ICC, and functional domain papers provide operating context to support the identification of capabilities (second CBP demand). In particular, the ICC highlights the need for an integrated, comprehensive, adaptive, and networked force. Similarly, the more specific Functional Domain papers indicate the importance of a networked force. For example, the Sustain Functional Domain paper recommends moving from a cold-war supply chain system requiring large stockpiles towards an on-time networked logistic system.

From a systems engineering point of view, the concepts developed correspond to "Abstract Models" used to develop the system requirements from the stakeholder requirements (see Figure 8 where the list of models and their relation with requirements development is shown). This type of model is typically used to provide the basis for establishing a common understanding of the proposed solution, albeit at an abstract level. It can be used to explain the solution concepts to those stakeholders who wish to be assured that the developers are moving in the right direction. Therefore, it ought to be precise with regards to the direction entailed by the proposed concept.

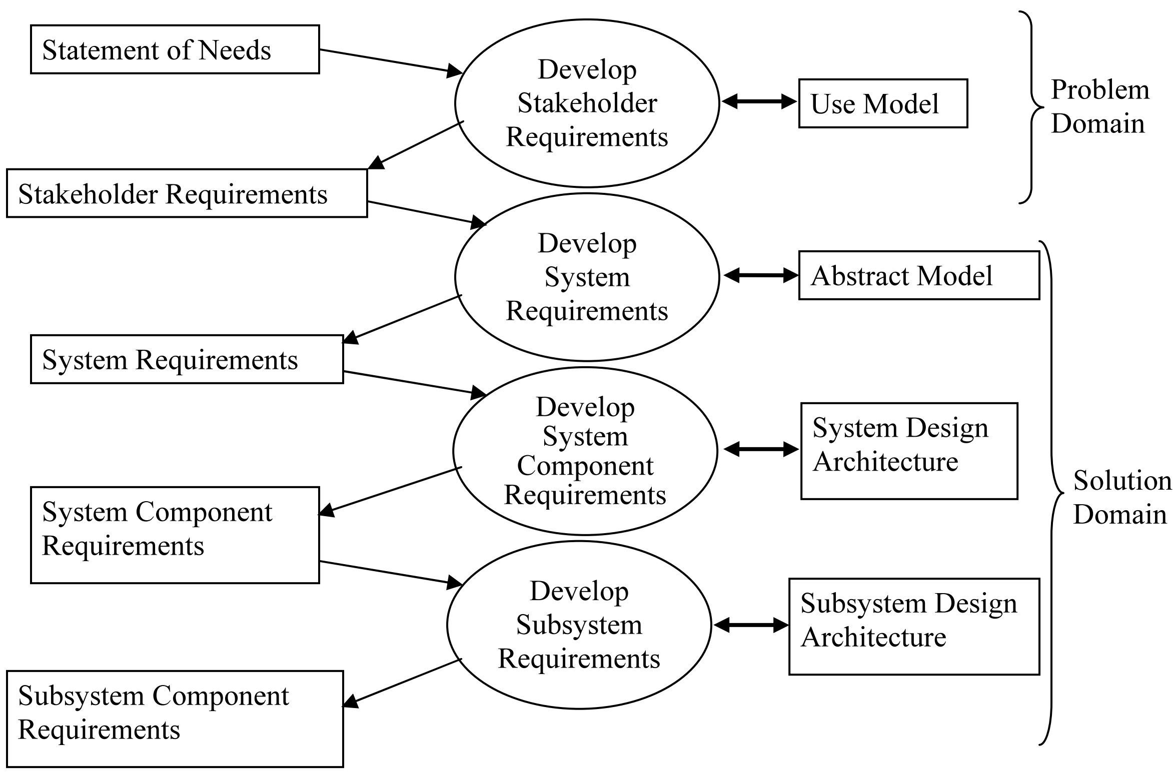


*Figure 8: List of models used in systems engineering*

It is worth noting that in systems engineering the abstract model does not appear first but it is actually preceded by a “Use Model”, which focuses on describing the problem space. This type of model does not appear explicitly within the CF force development process (Figure 4). In fact, a recent report indicated that the current concept development work lacks an epistemic approach that could be performed by leveraging the existing lessons learned process [14]. The introduction of models that capture lessons learned would fill this gap. A good starting point for developing these models should include a review of the simulation models developed by the U.S. Centre for Army Lessons Learned.

The requirement discussed on the abstract model for systems engineering shows some similarities with the Carnap criteria. Applying these criteria to concept development leads to the following requirements:

1. Realism. The concept must be based on realistic and achievable targets considering existing technology and available resources (human, financial, limited time). In particular, it must not require omnipotent and omnipresent soldiers capable of performing Herculean duties.

2. Exactness. The concept must be precise to be conveyed and understood by the broader force development community.

3. Fruitfulness. The new concept should enable us to draw meaningful conclusions and have important insights with regards to force development objectives. In particular, it should be balanced by considering any possible trade-off: a specific development direction necessarily entails moving away from other development directions.

4. Simplicity. The concept should be as simple as requirements 1 to 3 permit. Simplicity often accompanies the systematic power of concepts and aids in their ease of application and avoidance of errors in their application.

The implications of these four requirements are described in the following sub-sections. Note that the need for realistic and achievable targets was shown to be one important reason for the failure of projects (see Table 2).

### 4.4.1 From Status Quo to Blue Sky (Fruitful but Realistic)

A concept is a statement of how something might be done. Within the force development context, concepts are useful by proposing new ways to do more or better with less. However, concepts must be realistic and indicate the way for feasible improvements. If a proposed concept is too far fetched, it will be considered meaningless and the concept development activities will suffer in credibility. At the other extreme, concepts might propose new ways that do not lead to any improvements over the status quo, in which case, it would lead to changes for the sake of changes. The benefits expected from the implementation of the concept must be explicit. The ideal situation is for the concept to propose changes that are at least asymptotically reachable within the next 10 to 20 years.

The impact of a conceptual change on the force effectiveness over a period of time is illustrated in Figure 9 (the dashed line represents the anticipated long term force effectiveness and the curve represents the actual increase of effectiveness obtained through the implementation of the

concept). The concept development work is the first stage which leads to some recommended changes, which are implemented at a specific time ("Introduction" in Figure 9). Following some required education, the changes lead to some improvement to the force effectiveness. This improvement will not be as good as a "Blue Sky" view would presume, but should be significantly better than the status quo.

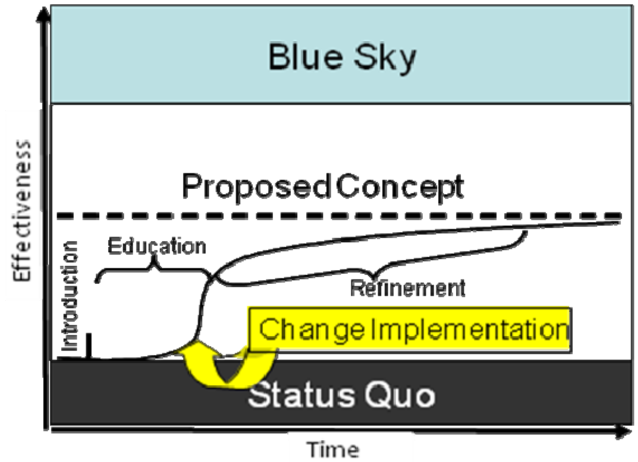


*Figure 9: Ideal concept effectiveness in view of feasibility*

The requirement for feasible concepts implies that one is aware of the natural limitations relevant to the considered concepts. On the physical side, there exist various natural limitations such as the impossibility to go faster than the speed of light ("*c*"), the indivisibility of electronic charges below the electron charge ("*e*") and the impossibility to reach into time and space scale below the Plank scale ("*h*"). These are very fundamental limitations. Similarly, on the electronic side, there exist various limitations based on current technology: magnetic recording of density higher than ~1 TB/in$^2$; magnetic reading and writing rate larger than 5 GHz; etc. It is also possible to estimate limitations to Random Access Memory and channel capacity based on current and foreseen technology.

However, much less is known with regards to natural human limitations. In many ways, some of these limitations are still unknown today and limitations considered valid in the past have been proven wrong. A draft paper is currently underway to identify factors impacting on human cognitive limitations [17].

### 4.4.2 Concept Precision (Degrees of Exactness)

An essential criterion proposed by Carnap is exactness. This criterion ensures that the concept is defined with sufficient precision for an observer to determine with a high level of confidence whether a concept is or is not implemented when observing the operators performing some tasks. Therefore, the concept description must be explicit about what it entails and also what it forbids.

However, it might be difficult in specific circumstances to determine if a concept is being implemented or not. For this reason, it is useful to define a scale that measures the degree of achievement of the concept. This scale can be continuous or discrete, such as the scale that was developed for Network-Enabled Capability by the NATO panel SAS-065 [18]. This scale should be simple enough to be communicated easily and should also pass the test of clairvoyance [12]. This test stipulates that a clairvoyant who could foresee the consequences of a specific implementation of the concept with no uncertainty shall be able to un-ambiguously assign a score to the outcome of the implementation.

Any developed concept should be precise enough to convey the rationale supporting the expected improved effectiveness implied by the concept. In addition, the concept description should provide the motivation and all assumptions that led to the proposed concept. In ideal circumstances, the proposed concept would answer identified lessons from past operations. It could also be based on best practices or from analogy with concepts employed by private firms or other organizations. The identification of the assumptions supporting the considered concept is essential to ensure that the validating experiments performed to assess the increase effectiveness obtained by implementing the concept are adequately designed.

### 4.4.3 No Free Lunch (Degrees of Fruitfulness)

In the area of machine learning (statistical inference) and optimization algorithms, the "No Free Lunch" theorem has been developed ([19], [20]). This theorem argues that there exists no generic algorithm that would be the best at solving all types of optimization problems. The same is likely true for concepts, which can be perceived as an "organizational algorithm" – a description of the method of how the organization, viewed as a system, is to perform specific tasks[4].

Considering the concept of network-enabled capability, as an example, the no-free lunch theorem would indicate that although optimal within specific circumstances, possible trade-offs imply varying benefits under varying circumstances. Limitations and risk associated with the network-enabled concept were reviewed in [21]. In particular, this reference highlights the risk that the network-enabled concept will lead to a Force too dependent on technology and an over-confident Commander making decisions based on an over-simplified picture of the battlespace.

Applying the no-free lunch theorem to the context of concept development highlights the need to consider and make explicit all possible trade-offs of new concepts. Only once these trade-offs are explicit can someone identify possible mitigating factors. If too many trade-offs are foreseen, this might indicate that the process required to enable the implementation of the concept might be too cumbersome or otherwise too risky. However, a definitive assessment of concepts is only possible through experimentation – the same applies to mathematical algorithms where the no-free lunch theorem has been developed (see reference [22]).

Figuring out the consequences of the implementation of a concept and the associated possible trade-offs are often the most difficult aspects required to assess a concept (which might explain why the lack of completeness of all requirements is often the most frequent reason for project failure as indicated in Table 2). Evangelos Triantaphyllou identified the following items as the main difficulties encountered when making strategic decisions [12]:

- Figuring out what aspects are important in evaluating the consequences of a decision;
- Determining the relative importance of the different aspects of the consequences; and,
- Dealing with the uncertainty about what consequences will result within a specific context.

When dealing with new concepts, one might have to accept a large level of uncertainty with regards to their consequences. Past experiments performed at the Canadian Forces Warfare

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[4] An algorithm is a method for solving a problem, which is similar to Schein's view of what motivates individuals to contribute to an organization [4].

Centre have clearly shown that unexpected and unforeseen results often arise when technical systems are tested on a larger scale in conjunction to existing systems.

#### 4.4.4 From Simple to Complex (Degrees of Simplicity)

As suggested by Carnap, a concept shall be as simple as possible while satisfying the requirements of exactness and fruitfulness. Even though the requirement of exactness and fruitfulness might lead to an over-complicated concept, it might still be possible to maintain some form of simplicity by building the concepts hierarchically using simpler ones.

Such a hierarchy of concepts was used within the U.S. Joint Forces Command Multinational Experiment 4 (MNE4) to study the concept of knowledge management [23]. The conceptual work started by developing a well-grounded definition of knowledge. Using the concept of proposition and interpretation as defined in predicate calculus [24], knowledge was defined as the interpretation of a proposition to which is associated a degree of belief. Based on this definition, a list of knowledge activities was defined as all possible types of activities which could impact on an individual's knowledge. Finally, knowledge management was defined as the set of processes that govern and facilitate the knowledge activities.

This construct for defining knowledge management provided a formal definition on which specific metrics were built to assess the knowledge management performed during the MNE4. Such precise definition is required to ensure an appropriate assessment of concepts within a campaign of experimentation. It also allowed a systemic assessment of the proposed concept by ensuring that all aspects of knowledge management were covered within the assessment.

### 4.5 Concept Categories

The various concepts should cover all interfaces identified within the Lawrence-Lorsch model to ensure that all organization aspects are adequately designed and improved. However, the current set of concepts (Integrated Capstone Concept, Integrating Concept, Operating Concept, and Enabling Concept) includes either large encompassing concepts such as the ICC or mission specific concepts. As with the Capability-Based Planning, the set of concepts does not cover the individual-organization interface. In fact, there is currently no specific set of concepts to handle strategic transformation, business transformation, personnel career management, or other daily management needs.

Therefore, organization development best practices suggest revising the list of families of concepts.

# 5 Experimentation

## 5.1 Experiment Definition

The term experiment comes from the Latin word 'Experiri', which means "to try". This definition describes precisely the general aim of experiments which consists of learning through explicit trials. This aim is the principle aspect which makes experimentation intrinsically different from exercises: while within an exercise operators are trained according to established doctrine, during an experiment new and unproven methods are tested. Experimentation is the only possible mechanism to firmly answer specific questions (or hypotheses). The way humans perceive and understand their surrounding environment is limited to an over simplified picture and often alternative theories can be proposed to explain observed phenomena. In many situations, experiments are necessary to select the most adequate theory.

Three different types of experiments are commonly done in support of military endeavours:

- Discovery experiment: Experiments aiming to **explore the potential benefits** of new methods (concepts) and of its underlying aspects and dependency on external factors.
- Hypothesis testing experiment: Experiments aiming to advance knowledge by seeking to **falsify or confirm specific hypotheses** as well as investigating the limitation of those hypotheses.
- Demonstration experiment: Experiments aiming to **display the benefits** of novel technologies, organization structure, or concepts of operations.

Often the various types of experiments are not performed individually, but within a larger campaign of experimentation which can include all three types. As the campaign of experimentation evolves the tested concept is refined and detailed (see Figure 10 from ref. [25]).

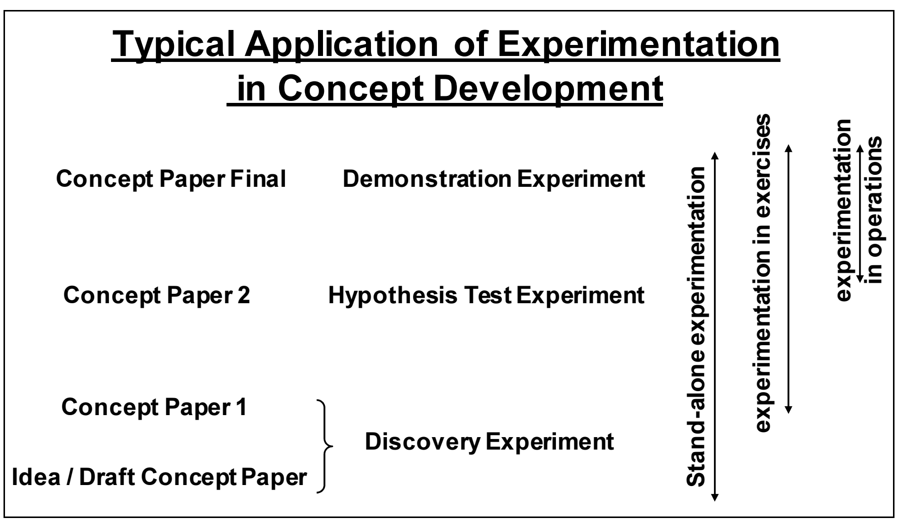


*Figure 10: Typical experiment campaign and its subsequent experiments*

The difference between hypothesis testing and discovery experiments is worth clarification. For all experiments, it is possible to write hypotheses or statements that can be tested within the experiment. However, within a proper hypothesis testing experiment, the hypotheses correspond to law-like or derivative law-like sentences [26]. Law-like sentences have four properties[5]:

1. They have universal form;

2. Their scope is unlimited (they can obviously be limited to a specific subject but not contextually);

3. They do not contain designations of particular objects (i.e., all designations are given to generic objects as opposed to specific ones), and

4. They contain only purely qualitative predicates.

A particularity of law-like sentences is that they support counterfactual tests (i.e., what would happen if…) and modal import (i.e., the law-like sentence delineates what is necessary, possible, or impossible). These properties limit the risk of accidental generalization since statements emerging from accidental generalizations do not support counterfactual tests or modal imports. This is a crucial distinction for laws have explanatory force, while accidental generalizations, even if they are true, do not.

Limitations to the hypotheses can also be included by using abnormic law-like sentences, i.e., law-like generalizations that contains an unless-clause. An example of an abnormic law-like sentence is: The velocity of an object does not change unless the net force on it is not equal to zero.

On the other hand, a discovery experiment focuses on identifying the aspects of interest of the studied phenomena. Its main role is to identify the essential elements that impact on the occurrence of the studied phenomena. To ensure all possible elements are included, discovery experiments need to be performed in a realistic environment. It is therefore common to perform discovery experiments within observational studies rather than within a laboratory setting. Within the Joint Fires Support (JFS) Technology Demonstration Project (TDP) experiments, the early discovery technical integration experiments were performed using existing Canadian Forces Command and Control systems rather than simulated systems that would have offered less complexity but would have not encapsulated all relevant elements.

The exact number of discovery, hypothesis testing, and demonstration experiments within a given campaign could vary substantially from one campaign to another. The more detailed and precise is the tested concept, the fewer the number of discovery experiments required. The number of hypothesis testing experiments typically depends on the breadth of the tested concepts. Finally, the number of demonstration experiments depends on the number of stakeholders and the variation of their interests.

In addition to designing the full campaign of experimentation, each individual experiment should be defined carefully as several issues can limit the validity of the experimental results. The usual

[5] These properties should be interpreted carefully. A statement such as "Gold is malleable" is law-like even if it refers to "Gold" since the statement is not limited to any particular gold objects.

approach to designing an experiment is described succinctly in Annex B and the reader is referred to the Guide for Understanding and Implementing Defense Experimentation (GUIDEX, [27]) for more details on experimentation best practices.

## 5.2 Experiment Components

Every experiment can be decomposed into five inter-related components: Treatment, Experimental Unit, Effect, Trial, and Analysis.

- **Treatment**. The treatment is the causal factor to be examined (e.g., the application of a new process or the use of new equipment to perform specific tasks). It is the object (abstract or concrete) that is expected to influence the experimental result.
- **Experimental Unit**. The experimental unit is the smallest unit assigned to the treatment (e.g., C-IED cell, sensor operator, etc.). It is the system or entity that performs the task required by the treatment.
- **Effect**. The effect is the dependent variable that relates to the expected impact of the treatment (e.g., target detected or not, time required for accomplishing the process, etc.).
- **Trial**. A trial is a single observation or instance of the test of the hypothesis. The experiment may consist of a single trial or multiple trials.
- **Analysis**. The analysis documents the outcome(s) of the trials, compares the differing conditions and treatments associated with those outcomes, and derives conclusions and recommendations.

The typical components tend to vary with the type of experiment. As an example, the initial discovery experiments performed within the JFS TDP focused on technical integration. The treatment was the integration of systems and the expected effect was a shared joint picture of the battlespace with limited latency. Following JFS experiments consisted in hypothesis testing experiments where the treatment was the developed integrated shared picture and coordination tools and the expected effects were improved shared situation awareness and a shorter response time to calls for fire support.

## 5.3 Experimentation Benefits to CBP

Experimentation uses real (or near-real, i.e., laboratory) environments to provide information and insights with a degree of certainty not available from other traditional means such as operational research or lessons learned analysis. Experimentation can provide evidence to verify whether specific concepts cause changes in military effectiveness. Essentially, the benefits of experimentation include:

- Reduced uncertainty (risk mitigation) with regards to the employment of new concepts (technology and methodology);
- Objective evaluation of innovations;
- Identification and possibly solution of practical problems that cannot be determined through studies and analysis alone (validation of suggested issues);

- Provision of empirical evidence to inform doctrine, policy, budgetary and procurement decisions (i.e., supporting evidence-based decisions); and,
- Support to force integration by enforcing the testing of new concepts and methodologies within a joint and/or coalition environment.

Considering these generic experimentation benefits within the scope of the CBP process, one deduces that experimentation could provide value to the CBP process by validating the mission analysis and the prioritization of capability within the “Capability Analysis” phase, as well as, by providing empirical evidence to confirm or recommended changes to the IDS priorities. Furthermore, an experimentation campaign is not only limited to the aspects considered within the CBP process but could also support the testing of new approaches designed to impact the individual-organization interface. However, new approaches impacting on the individual-organization interface might have effects over a long period of time which could be hard to estimate within the current type of experimentation performed. Adequate behavioural measurement tools, such as the Personal Value Questionnaire [28], would be needed to support this type of experiments.

Feedback from individuals who participated in past Joint Fires Support experiments indicates that experimentation actually plays a role in improving the individual-organization interface. In particular, military operators indicated that through their involvement in experiments they were brought to better appreciate the overall targeting process, the constraints imposed on it, and the potential avenues for improving this process. This appreciation from the operators that actions are taken to improve such process will likely pave the way for an improved individual-organization interface.

## 5.4 Experiment Requirements

To optimize the benefits of experimentation to the overall force development process, the experiment scenario must take into account the context of the future security environment.[6] Any experimentation campaign should also leverage modeling and simulation approaches since only a finite number of all possible operational settings can be tested within an experiment. To ensure an efficient use of experiments, one should identify and focus on the most relevant factors that will impact the experimental results. This means that planned experiments should leverage preceding experiments and available empirical data.

Furthermore, management science and computer science provide a wide variety of proven conceptual frameworks that can be used to guide military experiments. As discussed in section 2, there are various management science frameworks proposed by Lawrence and Lorsch, Thomson, Tannenbaum, Weick, Barki and Pinsonneault that could guide the instigation of organizational integration. Similarly, various frameworks for the integration of databases (Tight integration, Local As View, Global as View) have been developed and provide guidelines for such technical investigation. So far, only a small amount of assessment tools, such as the Command Team Effectiveness (CTEF) survey [29], has been developed using these frameworks. Other such tools, possibly leveraging recent development on Contingency Theory [30], should be developed to support the assessment of management aspects beyond those included within the CTEF survey.

[6] Solution to today’s war might not be ideal for tomorrow’s battles.

# 6 Conclusion

The intent of this report was to review the existing force development approach and compare the current joint force development approach with organization development best practices. In addition, the CD&E activities were also reviewed focusing on the contribution of such activities with a broad organization development framework.

The review of organization development science highlights the importance of diagnostic and systemic approach to guiding the force development activities. Empirical data indicates that a too narrow consideration (i.e., incomplete list of requirements) is among the most important causes of project failure (see Table 2). The comparative review of joint force development activities indicate two major weaknesses to the current approach: the lack of leverage of the lessons learned process to ensure a better consideration of the problem space and the lack of coverage of the individual-organization interface. These limitations to the current process also appear within the CD&E activities.

Based on the review of organization development literature, the following recommendations are made:

- The strategic and operational level lessons learned should be adequately institutionalized to ensure proper considerations of the problem space within the force development approach. This input to the force development approach should be made explicit within the overall process.
- Use models that describe the considered problem-space should be added to the type of concept models. These models should build on existing framework such as the one proposed by Lawrence and Lorsch.
- The force development approach should be done in a systemic fashion incorporating all aspects of the organization and in particular the individual-organization interface.
- Concept development should be compelling by recommending achievable targets;
- Concept should be precise enough for the larger CF community to clearly be able to identify whether it is applied or not when observing a group of operators performing the relevant operations;
- Concept development should be balanced by considering possible trade-offs to the investigated concept;
- Concept development should be logical by building on simpler concepts in a logical structure;
- Experiments should be contextually relevant using scenarios built according to conclusions from the future security environment; and,
- Additional assessment tools beyond currently used survey and data logs systems should be developed to support additional experimental aspects. In particular, the Personal Value Questionnaire as well as tools developed based on recent Contingency Theory work should be considered.

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# Annex A Department of National Defence Architecture Framework

The following table provides a brief explanation of the various views and sub-views within the DNDAF Version 1.7. The Defence Entreprise Architecture division is responsible for this list of views.

| View | Sub-View | Sub-View Name | General Description |
|---|---|---|---|
| **Common** | CV-1 | Overview and Summary Information | Scope, purpose, intended users, environment depicted, analytical findings |
| **Common** | CV-2 | Integrated Data Dictionary | Architecture data repository with definitions of key terms used in sub-views. |
| **Strategic** | StratV-1 | Business Strategy and Motivation | Identifies statements of strategic direction in order to guide and align the business to what it would like to become. |
| **Capability** | CapV-1 | Capability Taxonomy | Provides a structured list of capabilities activities and sub-activities that are required within a capability domain. |
| **Capability** | CapV-2 | Capability Scenario Analysis Matrix | Identification of relevant activities, the capability goals and the mission effects. The capability and mission effects assessment matrix. |
| **Operational** | OV-1 | High-Level Operational Concept Graphic | High-level graphical/textual description of operational concept |
| **Operational** | OV-2 | Operational Node Connectivity Description | Operational nodes, connectivity, and information exchange need lines between nodes |
| **Operational** | OV-3 | Operational Information Exchange Matrix | Information exchanged between nodes and the relevant attributes of that exchange |
| **Operational** | OV-4a | Organization Relationships Chart | Organization, role, or other relationships among organizations |
| **Operational** | OV-4b | Organization to Role/Skill Matrix | Roles related to Organizations for an architecture project. |
| **Operational** | OV-5a | Functional Model | A chart that breaks down “what” the user has to do to accomplish his/her mission. |
| **Operational** | OV-5b | Operational Process Model | A chart that breaks down the procedure that is followed among the functions in order to accomplish the mission. |
| **Operational** | OV-6a | Operational Rules Model | One of three sub-views used to describe operational activity—identifies business rules that constrain operation |

| View | Sub-View | Sub-View Name | General Description |
|---|---|---|---|
| **Operational** | OV-6b | Operational State Transition Description | One of three sub-views used to describe operational activity—identifies business process responses to events |
| **Operational** | OV-6c | Operational Event-Trace Description | One of three sub-views used to describe operational activity—traces actions in a scenario or sequence of events |
| **Operational** | OV-7 | Logical Data Model | Documentation of the system data requirements and structural business process rules of the Operational View |
| **System** | SV-1 | Systems Interface Description | Identification of systems nodes, systems, and system items and their interconnections, within and between nodes |
| **System** | SV-2 | Systems Communications Description | Systems nodes, systems, and system items, and their related communications lay-downs |
| **System** | SV-3 | Systems-Systems Matrix | Relationships among systems in a given architecture; can be designed to show relationships of interest, e.g., system-type interfaces, planned vs. existing interfaces, etc. |
| **System** | SV-4 | Systems Functionality Description | Functions performed by systems and the system data flows among system functions |
| **System** | SV-5 | Operational Activity to Systems Function Traceability Matrix | Mapping of systems back to capabilities or of system functions back to operational activities |
| **System** | SV-6 | Systems Data Exchange Matrix | Provides details of system data elements being exchanged between systems and the attributes of that exchange |
| **System** | SV-7 | Systems Performance Parameters Matrix | Performance characteristics of System View elements for the appropriate time frame(s) |
| **System** | SV-8 | Systems Evolution Description | Planned incremental steps toward migrating a suite of systems to a more efficient suite, or toward evolving a current system to a future implementation |
| **System** | SV-9 | Systems Technology Forecast | Emerging technologies and software/hardware sub-views that are expected to be available in a given set of time frames and that will affect future development of the architecture |
| **System** | SV-10a | Systems Rules Model | One of three sub-views used to describe system functionality—identifies constraints that are imposed on systems functionality due to some aspect of systems design or implementation |

| View | Sub-View | Sub-View Name | General Description |
|---|---|---|---|
| **System** | SV-10b | Systems State Transition Description | One of three sub-views used to describe system functionality—identifies responses of a system to events |
| **System** | SV-10c | Systems Event-Trace Description | One of three sub-views used to describe system functionality—identifies system-specific refinements of critical sequences of events described in the Operational View. |
| **System** | SV-11 | Physical Schema | Physical implementation of the Logical Data Model entities, e.g., message formats, file structures, physical schema. |
| **Technical** | TV-1 | Standards Profile | The listing of standards that apply to a system or its components. |
| **Technical** | TV-2 | Standards Forecast | The description of emerging standards and potential impact on a system or its components, within a set of time frames. |
| **Information** | IV-1 | Strategic Information Model | A diagram and supporting definitions that describes the relationships between significant high-level groups of data (information) and the rules and constraints that apply. |
| **Information** | IV-2 | Information Accountability Matrix | Details the accountabilities of the information stewards, and data stewards. It also depicts the relationships between subject areas and the accountability elements. |
| **Security** | SecV-1 | Risk Assessment | Documents the association of threats, risks and the resulting security control objectives. |
| **Security** | SecV-2 | Data Element Security Matrix | Listing of all data elements used by the architecture along with its security parameters. Included in these parameters are a means of documenting the aggregated security implications for each data element. |
| **Security** | SecV-3 | Aggregated Information Security Matrix | A listing of all system data exchanges used by the architecture that may cause potential information aggregation security violations. |

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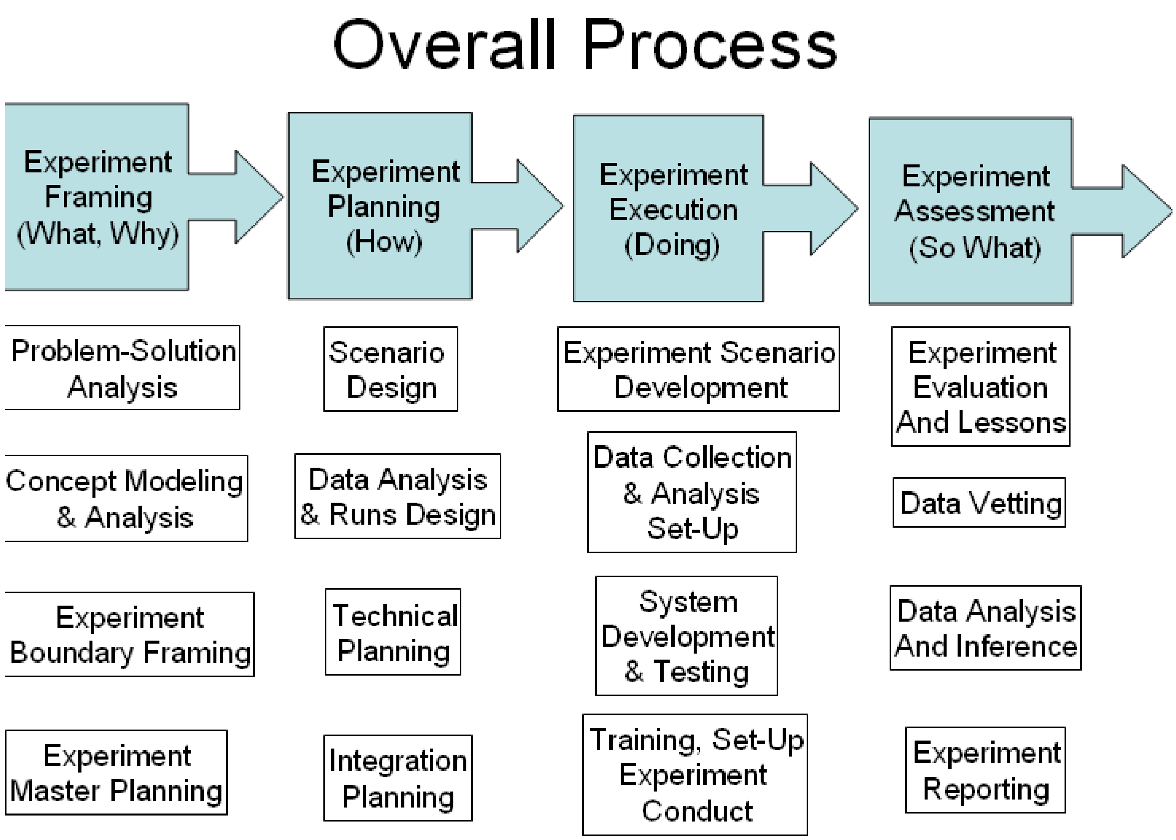
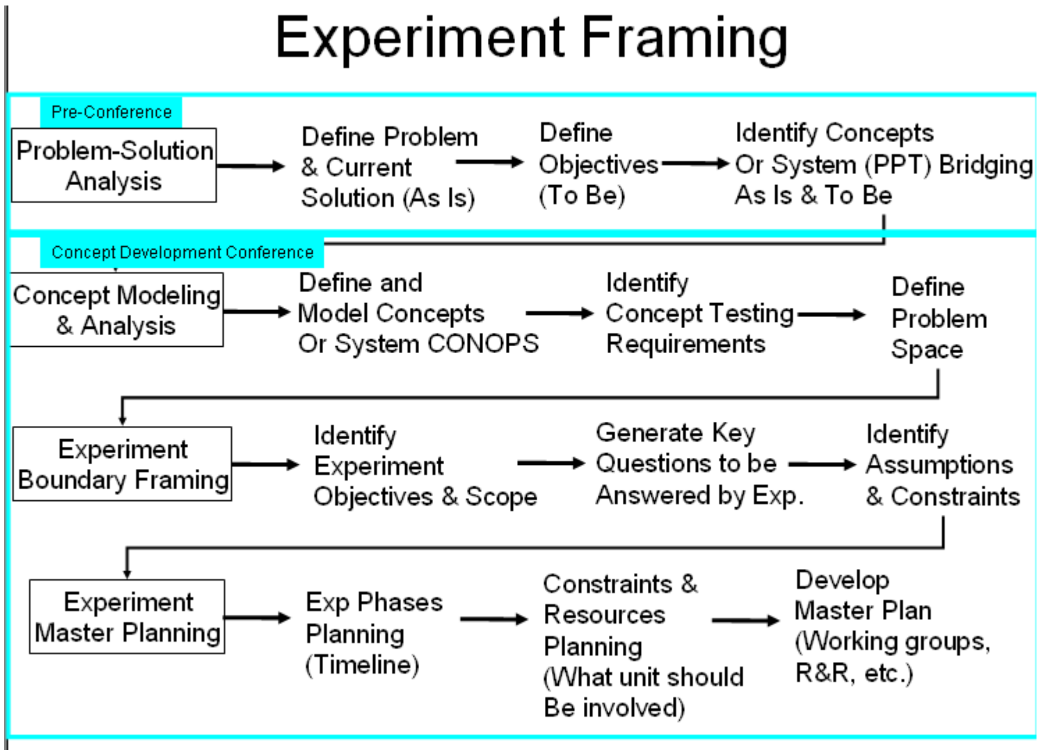
# Annex B Overview of Experimentation Steps

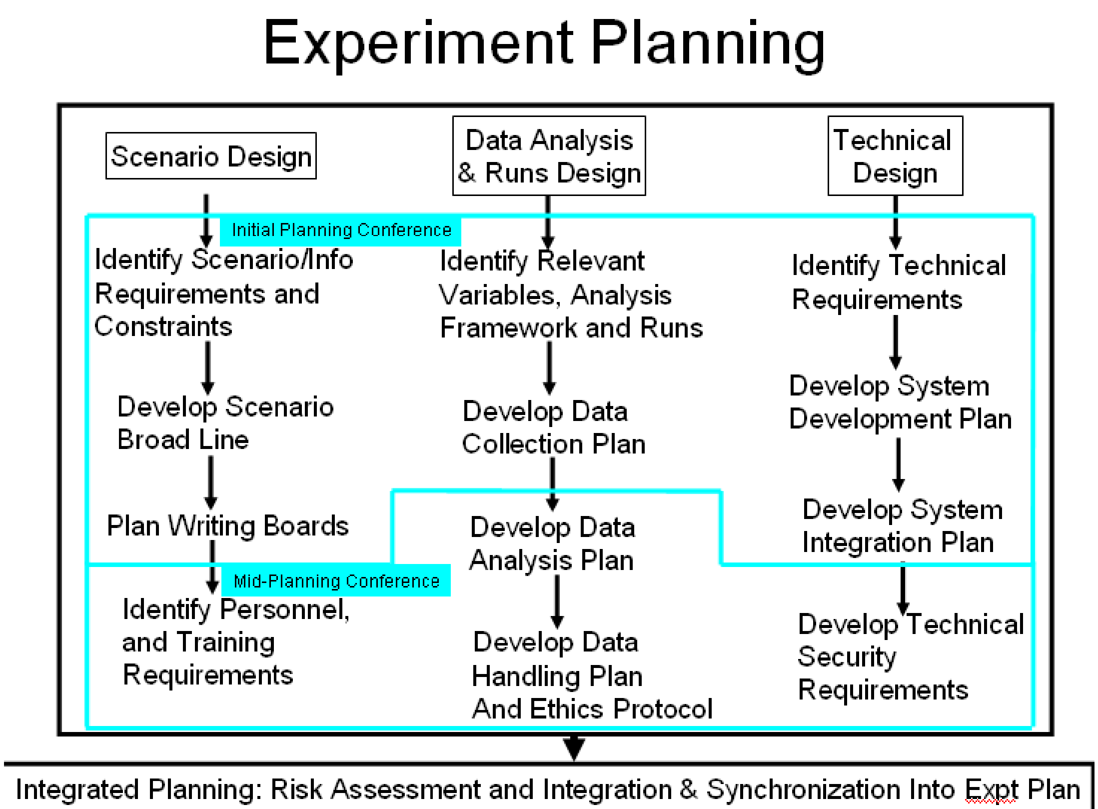
This annex provides a brief overview of the process used for designing experiments. The experiment process described in this annex described the approach used at the Canadian Forces Warfare Centre. This process shows many similarities with the approach suggested within the GUIDEx [27] but is more detailed. Four consecutives phases are used:

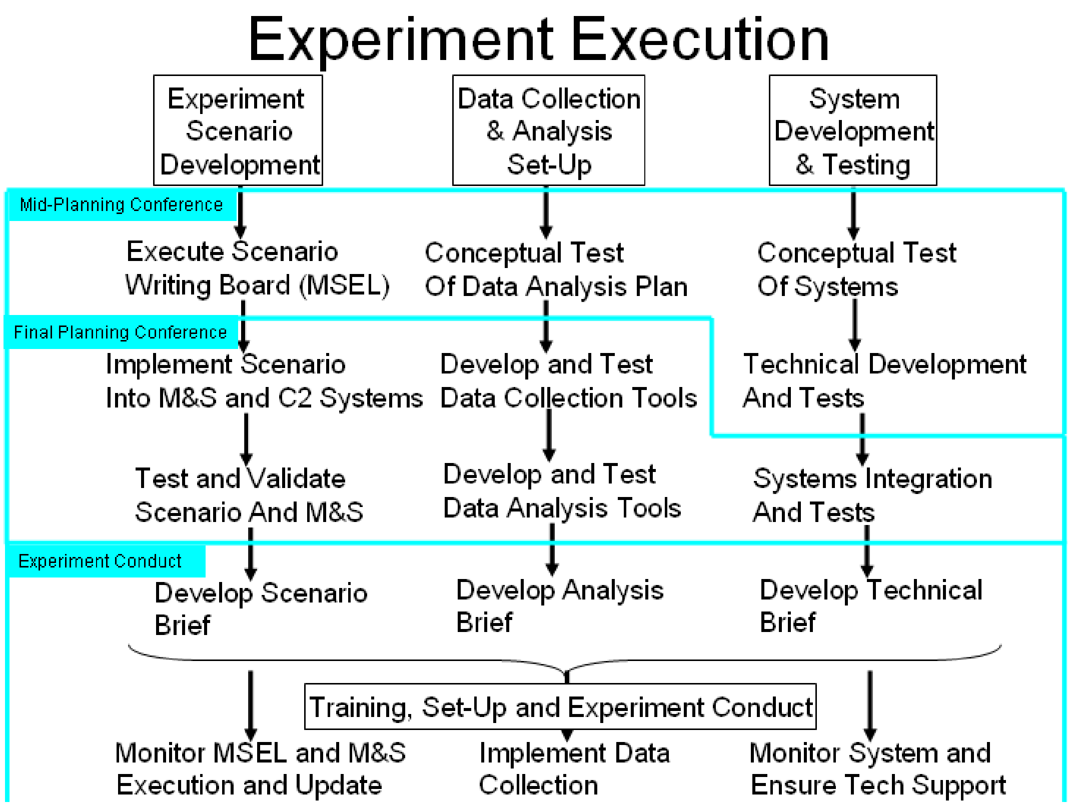
- Experiment framing: identifying what concept and methodologies will be tested and what are the experiment objectives.
- Experiment planning: Determining what needs to be done and how to proceed.
- Experiment execution: Developing all the products required and performing the experiment.
- Experiment assessment: Analyzing the collected data and producing reports and presentations.

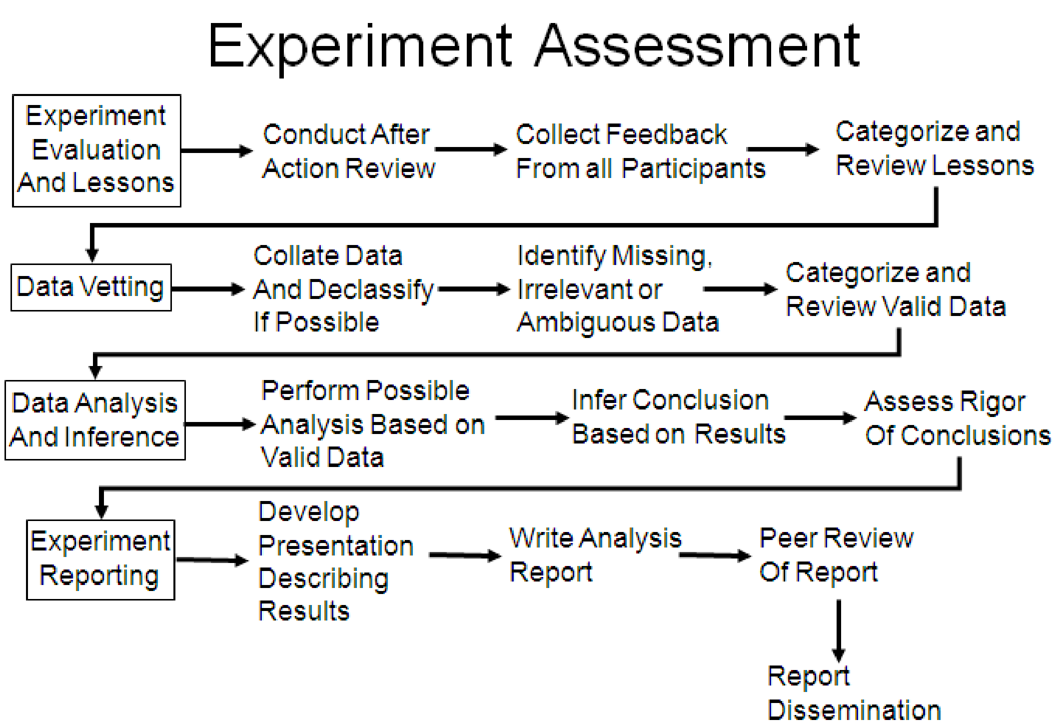
Each of these phases is illustrated below. Green lines are used to highlight the time frame in which each phase will be accomplished with regards to the occurrence of the Concept Design Conference, the Initial Planning Conference, the Mid-Planning Conference and the Final Planning Conference.




Experiment Framing
Pre-Conference
Problem-Solution Analysis
Define Problem & Current Solution (As Is)
Define Objectives (To Be)
Identify Concepts Or System (PPT) Bridging As Is & To Be
Concept Development Conference
Concept Modeling & Analysis
Define and Model Concepts Or System CONOPS
Identify Concept Testing Requirements
Define Problem Space
Experiment Boundary Framing
Identify Experiment Objectives & Scope
Generate Key Questions to be Answered by Exp.
Identify Assumptions & Constraints
Experiment Master Planning
Exp Phases Planning (Timeline)
Constraints & Resources Planning (What unit should Be involved)
Develop Master Plan (Working groups, R&R, etc.)


Experiment Planning
Scenario Design
Data Analysis & Runs Design
Technical Design
Initial Planning Conference
Identify Scenario/Info Requirements and Constraints
Identify Relevant Variables, Analysis Framework and Runs
Identify Technical Requirements
Develop Scenario Broad Line
Develop Data Collection Plan
Develop System Development Plan
Plan Writing Boards
Develop Data Analysis Plan
Develop System Integration Plan
Mid-Planning Conference
Identify Personnel, and Training Requirements
Develop Data Handling Plan And Ethics Protocol
Develop Technical Security Requirements
Integrated Planning: Risk Assessment and Integration & Synchronization Into Expt Plan


Experiment Execution
Experiment Scenario Development
Data Collection & Analysis Set-Up
System Development & Testing
Mid-Planning Conference
Execute Scenario Writing Board (MSEL)
Conceptual Test Of Data Analysis Plan
Conceptual Test Of Systems
Final Planning Conference
Implement Scenario Into M&S and C2 Systems
Develop and Test Data Collection Tools
Technical Development And Tests
Test and Validate Scenario And M&S
Develop and Test Data Analysis Tools
Systems Integration And Tests
Experiment Conduct
Develop Scenario Brief
Develop Analysis Brief
Develop Technical Brief
Training, Set-Up and Experiment Conduct
Monitor MSEL and M&S Execution and Update
Implement Data Collection
Monitor System and Ensure Tech Support


Experiment Assessment
Experiment Evaluation And Lessons
Conduct After Action Review
Collect Feedback From all Participants
Categorize and Review Lessons
Data Vetting
Collate Data And Declassify If Possible
Identify Missing, Irrelevant or Ambiguous Data
Categorize and Review Valid Data
Data Analysis And Inference
Perform Possible Analysis Based on Valid Data
Infer Conclusion Based on Results
Assess Rigor Of Conclusions
Experiment Reporting
Develop Presentation Describing Results
Write Analysis Report
Peer Review Of Report
Report Dissemination

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# List of acronyms

| | |
|---|---|
| AOC | Air Operating Concept |
| C4 | Command, Control, Communication, and Computers |
| CBP | Capability Based Planning |
| CD&E | Concept Development and Experimentation |
| CDI | Chief of Defence Intelligence |
| CF | Canadian Forces |
| CFD | Chief of Force Development |
| CFWC | Canadian Forces Warfare Centre |
| CM | Capability Management |
| CogOC | Cognitive Operating Concept |
| COPS | Collaborative Operation Planning System |
| CyOC | Cyber Operating Concept |
| DND | Department of National Defence |
| DNDAF | Department of National Defence Architecture Framework |
| DRDC | Defence Research & Development Canada |
| EC | Enabling Concept |
| FD | Force Development |
| FE | Force Employment |
| FSE | Future Security Environment |
| GUIDEx | Guide for Understanding and Implementing Defence Experimentation |
| ICC | Integrated Capstone Concept |
| IDS | Investment, Divestment and Sustainment |
| IP | Investment Plan |
| IT | Information Technology |
| JCD&E | Joint Concept Development and Experimentation |
| JIIFC | Joint Information and Intelligence Fusion Capability |
| JFS | Joint Fires Support |
| KLE | Key Leader Engagement |
| LL | Lessons Learned |

| | |
|---|---|
| LOC | Land Operating Concept |
| M&S | Modeling and Simulation |
| MOC | Maritime Operating Concept |
| OC | Operating Concept |
| OR | Operational Research |
| Org | Organization |
| OV | Operational Views |
| PD | Personnel Development |
| R&D | Research and Development |
| SCR | Strategic Capability Roadmap |
| SOC | Special forces Operating Concept |
| SOF | Special Operations Forces |
| TDP | Technology Demonstration Program |
| TTCP | The Technical Cooperation Program |

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Force development activities play a major role in ensuring that the Canadian Forces evolve and adapt to meet future mission requirements. However, the various joint force development activities (capability-based planning, concept development and experimentation) are not closely integrated and frequent changes to these activities have been performed in the past years. With the intent of guiding future potential changes, this report provides best practices on organization development based on a review of the scientific literature. An assessment of the current joint force development activities and their limitations is then performed. Finally, the paper provides recommendations with regards to Concept Development and Experimentation and how these activities can best contribute to the force development objectives.

The report highlights the various aspects that should be part of a systemic force development activity. It is found that some of these aspects are currently ignored within the current capability-based planning approach. These aspects are also used to recommend specific human views that should be included the Department of National Defence Architecture Framework. The report also highlights that concept development should deliver well define and precise concepts for which all potential trade-offs have been clearly identified.

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Concept Development, Experimentation, Force Development, CD&E, Campaign of Experimentation, Organization Development

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